

SECTION 02200

EARTHWORK

PART 1 - GENERAL

1.01 SCOPE

A. The Contractor shall furnish all labor, materials, tools, supervision, transportation, and installation equipment necessary to perform all related work as specified, herein, as shown on the Drawings.

B. The work of this Section shall include, but not necessarily be limited to: excavating, separating, hauling, stockpiling, backfilling, compacting and grading of soils. The work of this Section may pertain in whole or in part to construction of the following: subgrade preparation, embankment fill placement, final cover system construction, drainage structures and channels and general site grading.

The Contractor is advised that related sections contain additional detailed specifications and testing requirements for the various layers of the landfill cap and drainage structures to be installed and constructed under this project.

C. The Contractor shall conform to the dimensions, lines and grades indicated on the Drawings.

D. Excavations into the landfill may create hazardous conditions due to the presence of methane gas and other organic compounds. The Contractor shall be responsible for continuously monitoring conditions associated with the excavation and shall employ appropriate health and safety protocol for the protection of the Contractor's employees and all subcontractors. The Contractor shall implement all applicable provisions of his Health and Safety Plan as required under Section 01036 of these specifications.

1.02 RELATED SECTIONS

- A. Section 02210 - Sand
- B. Section 02220 - Riprap
- C. Section 02240 - Drainage Structures
- D. Section 02290 - Topsoil and Seed
- E. Section 02500 - HDPE Geomembrane Liner
- F. Section 02596 - Geotextile Filter Fabrics
- G. Section 02715 - Corrugated Polyethylene Pipe

1.03 PROTECTION

- A. The Contractor shall protect trees, shrubs, lawns and other features remaining as part of final landscaping.
- B. The Contractor shall protect benchmarks, survey markers, fences, roads, sidewalks, paving, curbs and other existing structures from damage due to the Contractor's activities.
- C. The Contractor shall repair damage caused by the construction operations at his cost.
- D. Erosion control must be maintained. Erosion control measures shall be implemented in conformance with the minimum guidelines presented on the Drawings. These controls include, but are not limited to the installation and maintenance of haybales and silt fence at the perimeter of the landfill along the northerly easterly and westerly perimeter of the landfill and at the area downgradient of the venal pool storm water discharge structure.

1.04 REFERENCES

- A. Latest version of American Society for Testing and Materials (ASTM) Standards:
 - 1. ASTM D 422 Standard Test Method for Particle-Size Analysis of Soils
 - 2. ASTM D 698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.
 - 3. ASTM D 1556 Standard Test Method for Density and Unit Weight of Soil In Place By the Sand-Cone Method.
 - 4. ASTM D 1557 Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.
 - 5. ASTM D 2216 Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.
 - 6. ASTM D 2487 Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).
 - 7. ASTM D 2922 Standard Test Methods for Density of Soil and Soil-Aggregate In Place By Nuclear Methods (Shallow Depth).
 - 8. ASTM D 2937 Standard Test Method for Density of Soil In Place By the Drive-Cylinder Method.
 - 9. ASTM D 3017 Standard Test Method for Water Content of Soil and Rock In Place By Nuclear Methods (Shallow Depth).

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| 10. | ASTM D 4220 | Standard Practices for Preserving and Transporting Soil Samples. |
| 11. | ASTM D 4318 | Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. |

1.05 EXISTING UTILITIES, STRUCTURES AND FACILITIES

- A. The locations of existing underground structures as shown on the Drawings are approximate only and are shown only for the convenience of the Contractor, who must verify the information to his own satisfaction. The Owner disclaims any responsibility for the accuracy or completeness of the information shown on the Drawings with regard to existing underground utilities or structures, and the Contractor shall not be entitled to any additional compensation because of inaccuracy or incompleteness of such information.
- B. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, the Contractor shall inform the Owner of such piping or utility immediately. The Contractor shall make modifications as approved by the Owner.
- C. The Contractor shall be held responsible for the cost of repairing all utilities, structures and subsurface drains which become damaged due to his construction operations, whether or not they appear on the Drawings. The notification of all utility companies before the start of work and the locating of underground structures which may be encountered during the course of construction are the responsibilities of the Contractor. All costs, including the costs of services of representatives of the affected utilities, incurred in such location operations shall be included in the work to be done under this Contract.
- D. Furnish all the necessary equipment and assume the entire cost of handling any water from storm, surface and flood flows which may be encountered at any time during construction of the work. The manner of providing for these flows shall meet with the approval of the Owner, and the entire cost of said work shall be included in the work to be done under this Contract.
- E. Should it become necessary to permanently or temporarily move any conduits, pipes, wires or structures in order to permit the Contractor to execute the work, the Contractor shall notify the Owner of the location and circumstances, and shall cease work if necessary, until satisfactory arrangements have been made by the owners of said obstructions to properly care for the same. No claims for damages shall be allowed on account of any delay occasioned thereby. The entire cost of the changes or temporary removal shall be included in the work to be done under this Contract.
- F. The Contractor shall, at his own expense, shore up and protect any poles, or other public or private structures which may be encountered or endangered in the prosecution of the work, and that may not be otherwise provided for, and he shall repair and make good any damages caused to any such property by reason of his operations. All existing structures which due to the prosecution of the work are

removed shall be replaced by the Contractor. No extra payment will be made for said work or material.

1.06 SUBMITTALS

- A. The Contractor shall submit to the Owner the required information and samples for all proposed fill materials a minimum of 14 days prior to delivery of the material to the Site, unless otherwise approved by the Owner.

1.07 SOURCE QUALITY CONTROL

- A. All fill and backfill materials shall be procured from off site sources unless otherwise approved or allowed in these specifications. Approval of materials will be based on tests performed by the Contractor's independent testing laboratory.
- B. Testing laboratory will determine maximum dry density and optimum water content of fills in accordance with ASTM D 1557. Provide samples of each fill material from proposed source of supply. Allow sufficient time for testing and evaluation of results before material is needed. Submit samples from alternate source(s) if required.

1.08 PRODUCT DELIVERY AND HANDLING

- A. Handling Materials: Keep public roads clear of all spillage from trucks hauling earthwork materials either from or to project site.

1.09 SUB-GRADE SOIL TESTING REQUIREMENTS

- A. CONTRACTOR shall retain the services of a qualified geotechnical laboratory to conduct quality control/assurance tests on samples of Subgrade Layer Soil.

CONTRACTOR shall conduct a minimum of one grain size test (ASTM D422) on a representative sample of each source of Subgrade Layer Soil. This testing shall be conducted prior to the delivery of Subgrade Layer Soil to the project site.

CONTRACTOR shall conduct shear tests (ASTM D-5321) to determine the strength of the interface between each source of the Subgrade Layer Soil and a sample of the geomembrane to be used for the project. Each test shall determine interface strength at normal stresses of 0.5 pound per square inch (psi), 2 psi and 4 psi. Additional testing shall be required if the Subgrade Layer Soil source has changed or the characteristics of the source have changed. Additional samples shall be collected and tested if the material does not meet specifications as of Part 2.01 of this Section at no cost to the OWNER. The CONTRACTOR shall conduct direct shear tests (ASTM D-3080) to determine the internal shear strength of the sub-grade materials. Each test shall determine internal strength at normal stresses of 0.5 pound per square inch (psi), 2 psi and 4 psi.

CONTRACTOR shall conduct hydraulic conductivity testing of the subgrade material at a frequency of 1 test/3000 cubic yards.

1.10 JOB CONDITIONS

- A. Contractor shall examine the site prior to submitting his Bid, taking into consideration all conditions that may affect his work. The Owner will not assume responsibility for variations of subsoil quality or conditions.
- B. Contractor shall barricade open excavations occurring as part of this work, and shall post and operate warning lights as recommended by authorities having jurisdiction.
- C. Contractor shall protect structures, utilities, sidewalks, pavements, and other facilities, not designated to be demolished, from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.

PART 2 - PRODUCTS

2.01 GENERAL

- A. This section specifies those classes of soils most commonly used or encountered in earth work construction. The Contractor shall use or furnish such types as are called for on the Drawings and/or in the Specifications.

2.02 SELECT GRANULAR FILL

- A. Select granular fill shall be natural mineral soil consisting of durable granular aggregates. The gradation of the soil shall conform to the limits specified below. The material shall be obtained from approved sources.

1. Granular Fill: Clean granular fill for use under footings and slabs-on-grade, subbase or and elsewhere as specified or indicated shall conform to the following gradation requirements:

<u>Square Sieve Size</u>	<u>Percent Finer By Weight</u>	
	Borrow	Subgrade Borrow
6-inch	100	--
3-inch	--	100
2-inch	90-100	--
1 1/2-inch	--	70-100
1/2-inch	--	50-85
No. 4	20 to 65	30-60
No. 200	0 to 12	0-10

Excavated material falling within the above requirements may be stored in segregated stockpiles for use as granular fill.

2.03 PIPE BEDDING MATERIAL

- A. Fine Gravel Bedding: Clean gravel for pipe bedding and elsewhere as specified or indicated shall conform to the following gradations requirements:

<u>Square Sieve Size</u>	<u>Percent Finer By Weight</u>
3/4-inch	100
3/8-inch	40 to 85
No. 4	15 to 60
No. 10	0 to 20
No. 200	5 maximum

2.04 PROCESSED AGGREGATES

- A. Processed aggregates shall be obtained or produced from approved sources and shall consist of granular mineral soils having gradations as specified below:

1. Washed Sand

<u>Sieve Size</u>	<u>Percent Finer by Weight</u>
3/8-inch	100
No. 4	70 to 100
No. 200	0 to 5

2. Crushed Stone

<u>Sieve Size</u>	<u>Percent Finer by Weight</u>				
	Peastone (1/4")	Grad. A (3/4")	Grad. B (1-1/4")	Grad. C (1-1/2")	Grad. D
6 inch	---	---	---	---	95 - 100
3 inch	---	---	---	---	10 - 30
2-inch	---	---	---	100	---
1-1/2-inch	---	---	100	95-100	---
1-1/4-inch	---	---	85-100	---	---
1-inch	---	100	---	35-70	---
3/4-inch	---	90 - 100	10 - 40	0-25	---
1/2-inch	100	10-50	0-8	---	---
3/8-inch	85 - 100	0-20	---	---	---
No. 4	20 - 50	0-5	---	---	<10
No. 8	0 - 15	---	---	---	---
No. 16	0 - 5	---	---	---	---

- a. For crushed gravel, at least 50 percent of the materials retained on the 1-inch sieve shall have a fractured face.

3. Screened or Crushed Gravel

<u>Sieve Size</u>	<u>Percent Finer by Weight</u>		
	Type A	Type B	Type C

	Aggr.	Aggr.	Aggr.
1/2 inch	45 to 70	35 to 75	
No. 4	30 to 55	25 to 60	25 to 70
No. 40	0 to 20	0 to 30	0 to 30
No. 200	0 to 5	0 to 5	0 to 5

- a. Type A aggregates for base shall not contain particles of rock which will not pass the 2-inch square mesh sieve.
- b. Type B aggregate for base shall not contain particles of rock which will not pass the 4-inch square mesh sieve.
- c. Type C aggregate for base shall not contain particles of rock which will not pass the 6-inch square mesh sieve.

2.05 PROCESSED RECYCLED MATERIALS

- A. Processed recycled materials shall consist of hard, durable angular shaped materials which are the product of the primary crushing of asphalt, brick and concrete. Rounded materials, boulders or soft stone or irregularly thin slabs will not be acceptable. The processed recycled materials shall be free from overburden, spoil, organic material, metals, plastics or other deleterious debris and shall meet the following gradation requirements:

Size of particles	Passing Percentage
8 In.	95-100
4 in.	0-25
2-1/2	0-5

PART 3 - EXECUTION

3.01 PREPARATION

- A. Remove all unsuitable material including topsoil, fill, organic soils and waste within areas upon which granular fill is to be placed.
- B. In cross country areas within which excavations are to be made, cover material, loam and topsoil shall be carefully removed and separately stored to be used again as directed.
- C. The Contractor shall make excavations in such manner and to such widths as will give suitable room for building the structures or laying and joining pipe; shall furnish and place all sheeting, bracing, and supports; shall do all pumping, and draining; and shall render the bottom of the excavation firm and dry and in all respects acceptable.
- D. In no case shall the earth be plowed, scraped, or dug by machinery so near to the finished grade at the bottom of the excavation as to result in disturbance of

material below said grade. All loose material shall be removed from the bottom of the excavation so that the bottom shall be in an undisturbed condition. If removal of the loose material results in excavation beyond the limits shown on the Drawings and over excavation has not been ordered, the restoration of the excavation to grade shall be done at no additional cost to the Owner.

3.02 LANDFILL SURFACE PREPARATION

- A. The Contractor shall conduct landfill surface preparation with the intent of utilizing existing cover soils as much as possible. Select granular fill provided by the Owner will be used to bring areas to grade, as directed by the Owner. Organic or vegetative support soils shall be striped from the landfill surface and stockpiled on site, in a location directed by the Owner.
- B. The Contractor shall not damage the existing facilities and shall repair all damage to them in accordance with the specifications.
- C. The Contractor shall rough grade the landfill cap subgrade surface and adjacent areas to required levels, profiles, contours and elevations ready for finish subgrading.
- D. Grading shall be done by bulldozer or other appropriate means. Areas adjacent to structures and other areas inaccessible to heavy grading equipment shall be graded by hand.
- E. The landfill surface, including sideslopes of the existing landfill areas shall be fine graded to a smooth and uniform surface free from depressions and high spots conforming generally to the slopes indicated on the Drawings. The surface shall then be thoroughly compacted. Landfill surface compaction shall be provided by a minimum of four complete passes of a 10 ton vibratory smooth compaction equipment traveling at a speed of not greater than 5 miles per hour.
- F. Upon completion of vibratory compaction the prepared area shall be rolled smooth free of ruts and depressions to a dense and uniform surface.
- G. The prepared landfill surface shall be proof rolled in order to demonstrate that the compaction effort has been successful and that no soft spots remain.
- H. Proof rolling shall be conducted by the Contractor utilizing an articulated dump truck or equivalent which has been loaded to maximum capacity with soils material, (total weight 60 tons \pm).
- I. Proof rolling shall be conducted in the presence of the CQA Consultant. The intent of the proof roll is to identify soft or yielding areas within the existing landfill surface areas.
- J. Should the Owner determine that soft spots or yielding areas remain after the compaction effort is completed, corrective measures shall be taken. These measures shall include the excavation of the yielding materials and backfill and

compaction with gravel borrow soils to suitable subgrade elevations. The affected area shall be re-tested to ensure adequate stabilization.

- K. The horizontal and vertical extent of all excavation shall be determined by the Owner.

3.03 EXCAVATION NEAR EXISTING STRUCTURES

- A. Attention is directed to the fact that there are existing pipes, drains, and other utilities in certain locations. An attempt has been made to locate all utilities on the drawings, but the completeness or accuracy of the information given is not guaranteed. Where such structures are not to be demolished, unless otherwise approved by the Owner, excavation work shall be conducted in accordance with this section.
- B. As the excavation approaches pipe, conduits, or other underground structures, digging by machinery shall be discontinued and the excavation shall be done by means of hand tools, as required. Such manual excavation when incidental to normal excavation shall be included in the work to be done under items involving normal excavation.
- C. Where determination of the exact location of a pipe or other underground structure is necessary for doing the work properly, the Contractor may be required to excavate test pits to determine such locations. When such test pits may be properly considered as incidental to other excavation, the Contractor shall receive no additional compensation, the work being understood to be included as a part of the excavation.

3.04 PROTECTION OF PROPERTY

- A. All surfaces which have been injured by the Contractor's operations shall be restored to a condition at least equal to that in which they were found immediately before work was begun. Suitable materials and methods shall be used for such restoration.

3.05 PROTECTION OF EXISTING STRUCTURES

- A. All existing pipes, poles, wires, fences, curbing, property line markers, perimeter gas ventilation trenches, monitoring wells and other structures not designated for demolition, unless otherwise approved by the Owner, which the Owner decides must be preserved in place without being temporarily or permanently relocated, shall be carefully supported and protected from injury by the Contractor. Should such items be injured, they shall be restored by the Contractor, without compensation therefore, to at least as good of a condition as that in which they were found immediately before the work was begun.

3.06 CARE AND RESTORATION OF PROPERTY

- A. The Contractor shall enclose the trunks of trees adjacent to his work and not to be cut, with substantial wooden boxes of such height as may be necessary to protect

them from injury from piled material, from equipment, from his operations, or otherwise due to his work. Excavating machinery and cranes shall be of suitable type and be operated with care to prevent injury to trees not to be cut and particularly to overhanging branches and limbs.

- B. Branches, limbs, and roots shall not be cut except by permission of the Owner. All cutting shall be smoothly and neatly done without splitting or crushing. In case of cutting or unavoidable injury to branches, limbs, and trunks of trees, the cut or injured portions shall be neatly trimmed and covered with an application of grafting wax or tree healing paint as directed.
- C. Cultivated hedges, shrubs, and plants which might be injured by the Contractor's operations shall be protected by suitable means or shall be dug up, balled and temporarily replanted and maintained. After the construction operations have been substantially complete, they shall be replanted in their original positions and cared for until growth is re-established. If cultivated hedges, shrubs, and plants are injured to such a degree as to affect their growth or diminish their beauty or usefulness, they shall be replaced by items of kind and quality at least equal to the kind and quality existing at the start of the work.
- D. On paved surfaces the Contractor shall not use or operate tractors, bulldozers, or other power-operated equipment the treads or wheels of which are so shaped as to cut or otherwise injure such surfaces.
- E. All surfaces which have been injured by the Contractor's operations shall be restored to a condition at least equal to that in which they were found immediately before work was begun. Suitable materials and methods shall be used for such restoration.
- F. The restoration of existing property and structures shall be done as promptly as practicable and shall not be left until the end of the construction period.

3.07 SHEETING AND BRACING

- A. The Contractor shall furnish, put in place, and maintain sheeting, bracing, etc., as may be necessary to support the sides of the excavation and to prevent any movement of earth which could in anyway diminish the width of the excavation to less than that necessary for safe and proper construction, or could otherwise injure or endanger adjacent structures or human life. If the Owner is of the opinion that at any point sufficient or proper supports have not been provided, he may order additional supports put in at the expense of the Contractor.
- B. The Contractor shall leave in place to be embedded in the backfill, or concrete, all sheeting, bracing, etc., in which the Owner may direct him in writing to leave in place.
- C. The Owner may direct that timber used for sheeting and bracing may be cut off at any specified elevation.
- D. Wherever possible, sheeting shall be driven ahead of the excavation to avoid loss of material from behind the sheeting. If it is necessary to excavate below the sheeting, care shall be taken to avoid trimming behind the face along which the

sheeting shall be driven. Care shall be taken to prevent voids outside the sheeting; but, if voids are formed, they shall be filled immediately with sand and compacted.

- E. All sheeting and bracing not to be left in place shall be carefully removed in such manner as to not endanger the construction or other structures. All voids caused or left by the withdrawal of sheeting shall be backfilled immediately with approved material and compacted.
- F. The right of the Owner to order sheeting and bracing left in place shall not be construed as creating any obligation on his part to issue such orders, and his failure to exercise his right to do so shall not relieve the Contractor from liability for damages to persons or property occurring from or upon the work as a result of negligence or other causes growing out of the Contractor's failure to leave in place sufficient sheeting and bracing to prevent any caving or moving of the ground.

3.08 TRENCH EXCAVATION

- A. Trench excavation, backfill and compaction shall be conducted in general accordance with these specifications and the Drawings.
- B. Trenches shall be excavated to such depths as will permit the pipe to be laid at the elevations, slopes, or depths of cover indicated on the drawings.
- C. Where pipe is to be laid in crushed stone bedding or concrete cradle, the trench may be excavated by machinery to, or to just below the designated subgrade, provided that the material remaining at the bottom of the trench remains undisturbed.
- D. Where pipe is to be laid directly on the trench bottom, the lower part of the trench in earth shall not be excavated to subgrade by machinery, but just before the pipe is to be placed, the last of the material to be excavated shall be removed by hand tools to form a flat or shaped bottom, true to grade, so that the pipe will have a uniform bearing and support on firm and undisturbed material between joints except for limited areas where the use of pipe slings may have disturbed the bottom.

3.09 TRENCH EXCAVATION IN FILL

- A. If pipe is to be laid in embankments or other recently filled material, the material shall first be placed to the top of the fill or to a height of at least 1 foot above the top of the pipe whichever is the lesser. Particular care shall be taken to ensure maximum consolidation of material under the pipe location. The pipe trench shall be excavated as though in undisturbed material. Material under the pipe location shall be compacted to 90 percent maximum density according to ASTM D1557, Method C.

3.10 WIDTH OF TRENCH

- A. Pipe trenches shall be made as narrow as practicable and shall not be widened by scraping or loosening materials from the sides. Every effort shall be made to keep

the sides of the trenches firm and undisturbed until backfilling has been completed and consolidated.

- B. Trenches shall be excavated with approximately vertical sides between the elevation of the center of the pipe and elevation 1 foot above the top of the pipe.

3.11 EARTH EXCAVATION AND BACKFILL BELOW NORMAL GRADE

- A. If, in the opinion of the Owner, existing material below trench grade is unsuitable for properly placing bedding material and laying pipe, the Contractor will excavate and remove unsuitable material to the required width and depth and replace it with granular fill as directed by the Owner.

3.12 UNAUTHORIZED EXCAVATION

- A. If the bottom of any excavation is taken out beyond the limits indicated or prescribed, the resulting void shall be backfilled at the Contractor's expense with thoroughly compacted specified borrow for pipeline not having a concrete encasement or cradle. For concrete structures and pipelines having concrete encasement or cradle, the void shall be filled with concrete with a minimum compressive strength of 3000 psi.

3.13 COMPACTION REQUIREMENTS

- A. The requirements for compaction of backfill shall conform to the following guidelines based on ASTM D1557 Method C:

<u>Location</u>	<u>Percent Maximum Density</u>
Below pipe midline	92
Above pipe midline	92
Below pipe in embankments	92
Below pavement (upper 3 feet)	95
Embankments	95
Adjacent to structures	92
Below structures	95
Landfill Liner Subgrade	90

- B. The Owner reserves the right to perform additional tests on any area.

3.14 STRUCTURAL EXCAVATION

- A. Excavate areas to the elevation indicated on Drawings or as may be required for the Contractor's selected equipment. Extend excavations a sufficient distance from structures to allow for placement and removal of forms, installation of services, and inspection.
- B. Slope sides of excavation maximum of 45 degrees from horizontal, except adjacent to existing structures.

- C. Final excavations shall be hand trimmed. Do not disturb soil below final excavation grades.
- D. Excavation shall not interfere with normal 45 degree bearing splay of foundations.
- E. Proof roll entire excavation.
- F. Remove soft areas of excavation discovered during proof rolling and backfill with granular fill as specified.
- G. Backfill excavation to required subgrade with suitable excavated materials or granular fill as specified.

3.15 BACKFILLING

- A. In general, and unless other material is indicated on the Drawings or specified or classified as unsuitable material by the Owner, excavated material removed in the course of the construction excavation shall be suitable material for backfilling trenches, waste removal areas, or filling to final subgrades.
- B. Care shall be exercised in placing fill adjacent to piers, walls, grade beams, footings, and other structures to prevent lateral movement. Fill on opposite sides of such items shall be kept at approximately the same elevation to prevent an unbalanced earth pressure, and shoring shall be used as necessary. Foundation walls and footings will not withstand unbalanced earth or equipment loadings.
- C. Frozen material shall not be placed in the backfill nor shall backfill be placed upon frozen material. Previously frozen material shall be removed or shall be otherwise treated as required, before new backfill is placed.
- D. All backfill shall be compacted to the specified percent of maximum density at optimum moisture as determined by ASTM D1557.
- E. Previously placed or new materials shall be moistened by sprinkling, if required, to ensure proper bond and compaction. No compacting shall be done when the material is too wet, from either rain or too great an application of water, to compact it properly; at such times the work shall be suspended until the previously placed and new materials have dried out sufficiently to permit proper compaction, or such other precautions shall be taken as may be necessary to obtain proper compaction.
- F. Material used for backfilling trenches or around structures shall be brought up to the grades as indicated on the drawings.

3.16 BACKFILLING PIPE TRENCHES

- A. As soon as practicable after pipes have been laid, backfilling shall be started. Pipeline cover shall be as indicated on the Drawings or directed by Owner.
- B. Pipe bedding shall be placed with hand shovel up to a level of 12-inches above the top of pipe. This area of backfill is considered the zone around pipe and shall

be thoroughly compacted before the remainder of the trench is backfilled. Compaction of the zone around pipe shall be done by use of power-driven tampers weighing at least 20 pounds and approved by the Owner. Care shall be taken that material close to the bank, as well as in all other portions of the trench, is thoroughly compacted.

- C. Granular fill shall be placed from the top of the select backfill to grade. Backfill and compaction in the remainder of the trench shall be done in layers not exceeding 12 inches in depth and by use of power driven tampers weighing at least 20 pounds and approved by the Owner. Water jetting and puddling will not be permitted.
- D. The Contractor shall maintain the trench surface as work progresses. If settlement takes place he shall immediately deposit additional material to restore the level of the ground.

3.17 BACKFILL GRADES

- A. Material used for backfilling trenches or around structures shall be brought up to normal grades.

3.18 FILL SUPPORTING STRUCTURES AND REQUIRED COMPACTION

- A. Material to be used as fill for supporting structures shall be Fine Gravel Bedding as directed and approved in advance by the Owner. Where fill is required to support proposed footings, wall, slabs, and any other structure, the material shall be placed and compacted in layers not to exceed 8 inches. Compaction of each lift shall be to a dry density of 95 percent of the maximum dry density determined by ASTM D1557 and shall be by hand-guided vibratory equipment or mechanical tampers.
- B. Following the placement and compaction of the fill material, crushed stone, if required, shall be placed immediately below the structures as detailed on the drawings.

3.19 BACKFILLING AROUND STRUCTURES

- A. The Contractor shall not place backfill against or on structures until they have attained sufficient strength to support the loads to which they will be subjected. Excavated material approved by the Owner shall be used in backfilling around structures and shall be compacted. Backfilling material shall be spread in horizontal layers not exceeding 9 inches in thickness (loose) and thoroughly compacted to at least 92 percent of the maximum dry density as determined by ASTM D1557.
- B. Tree stumps or roots more than 12 inches long or more than 1/2-inch in diameter and stones or rocks larger than 6 inches in greatest dimension shall not be considered suitable material for backfill around structures.
- C. Should an insufficient quantity of suitable material, as determined by the Owner, be available for backfill around structures, the Contractor shall use gravel borrow,

as approved by the Owner at no additional cost to the Owner.

3.20 ADDITIONAL GRANULAR FILL

- A. Should the Owner classify material above the trench bottom as unsuitable for backfill, and there is no available backfill material stockpiled, then the Owner shall order additional granular fill to be furnished and installed by the Contractor.
- B. Backfilling and compaction requirements for the granular fill shall otherwise conform to the trench details.

3.21 ADDITIONAL CRUSHED STONE

- A. Should the Owner order additional crushed stone for utility supports or for other purposes, the Contractor shall furnish and install the crushed stone as directed.

3.22 RESTORING TRENCH SURFACE

- A. Where the trench occurs adjacent to paved streets in shoulders or sidewalks, the Contractor shall compact as specified elsewhere in these specifications the backfill and shall maintain the surface as the work progresses. If settlement takes place he shall immediately deposit additional fill to restore the level of the ground,
- B. Adjacent to streets and highways the top 12-inch layer of trench backfill shall consist of compacted gravel base course. If in the opinion of the Owner, the existing top 12-inch layer is unsuitable for use as subgrade or shoulder material, he may order the Contractor to remove this layer and to backfill with gravel borrow compacted to at least 95 percent of maximum dry density as determined by ASTM D1557, Method D.

3.23 EMBANKMENTS AND STONE BUTTRESSES

- A. Perform all necessary foundation preparation including the removal of unsuitable materials from within areas of proposed embankment construction. These areas include the westerly side of the landfill beyond the base of the existing berm where the slope will be extended at a 2:1 slope and areas along the north side of the landfill where slope reduction to 1.5:1 and stone buttress construction is to be performed.
- B. All unreinforced backfill material used to reduce the steepness of the landfill slopes shall consist of materials that are free from organic or other unsuitable or deleterious material. The materials to be utilized in the construction of the unreinforced embankment slopes shall be comprised of rock fill or other inert material, such as broken concrete or brick, earthen materials or a combination of these components. Earthen materials proposed for use shall have no greater than 15% by weight passing the #200 sieve.

The material shall exhibit an angle of internal friction of not less than 40 degrees, as determined by the direct shear test ASTM D3080, utilizing as sample of the material compacted to 95% of ASTM D1557, at optimum moisture content.

The material shall have an organic content no greater than 1% (AASHTO T-267-86)

The frequency of sampling the unreinforced backfill necessary to assure the above mentioned requirement shall be directed by the Owner's Engineer

Surplus, uncontaminated, as determined by the Owner, excavated material available from the excavations and other on-site areas may be used for filling and constructing embankments, except as otherwise specified.

- C. Material needed in addition to that available from construction operations shall be furnished by the Contractor at his own expense, and shall conform to the requirements specified above.
- D. The Contractor shall remove loam and topsoil, loose vegetable matter, stumps, large roots, etc., from areas upon which embankments will be built or material will be placed for grading. The subgrade shall be shaped as indicated on the drawings and shall be so prepared so that the first layer of the new material placed there on will be well bonded to it.
- E. After the subgrade has been prepared as herein before specified, the material shall be placed thereon and built up in successive layers until it has reached the required elevation.
- F. Layers shall not exceed 12 inches in thickness (loose) and shall be compacted to at least 95 percent of the maximum dry density as determined by ASTM D1557, Method D. In embankments the layers shall be slightly dished toward the center.

Each layer of earthen material shall be compacted by the use of vibratory compaction equipment, rollers or other mechanical means to achieve at least 95 percent of maximum dry density as determined by ASTM D1557, Method D. At such points as cannot be reached by mobile mechanical equipment, the materials shall be thoroughly compacted by the use of suitable power-driven tampers.

- G. Stone Buttress construction shall be completed at the locations and in accordance with the details provided on the design drawings. Stone buttresses shall be constructed on a suitably prepared subgrade foundation that includes the installation of geotextile fabric.

Place the rock in a stable orientation with minimal voids. Offset the rock to produce a random pattern. Use spalls smaller than the minimum rock size to chock the larger rock solidly in position and to fill voids between the large rocks.

Construct the exposed face of the rock mass reasonably uniform with no projections beyond the line of the slope that are more than 12 inches.

3.24 SURPLUS EXCAVATED MATERIALS

- A. No excavated material shall be removed from the site of the work or disposed of by the Contractor except as directed or approved by the Owner. All surplus material

removed from the site shall be disposed of by the Contractor at the Contractor's expense.

- B. Surplus, uncontaminated, excavated materials shall, with the approval of the Owner, be used to backfill normal excavations in rock or to replace other materials unacceptable for use as backfill; shall be neatly deposited and graded so as to make or widen fills, flatten side slopes, or fill depressions; or shall be neatly deposited for other purposes indicated by the Owner, within its jurisdictional limits; all as directed or approved and without additional compensation.
- C. Surplus, uncontaminated, excavated material, other than that suitable for backfill, shall be neatly deposited for other purposes as indicated by the Owner, within its jurisdictional limits, as directed or approved and without additional compensation.
- D. Surplus, uncontaminated, excavated material not needed as specified above shall be hauled away and dumped by the Contractor; at his expense, at appropriate locations, and in accordance with arrangements made by him.
- E. Refuse and debris excavated during these operations shall be disposed of by the Contractor at a location within the limits of the landfill, as approved and directed by the Owner. The Contractor shall limit the disposal area to as small a section of the landfill as is possible.

3.25 DITCHES AND GUTTERS

Excavation of ditches, and gutters shall be accomplished by cutting accurately to the cross sections, grades, and elevations required. Excessive open ditch or gutter excavation shall be backfilled with satisfactory thoroughly compacted material or with suitable stone or cobble to grades shown at the Contractor's Expense. Material excavated shall be disposed of as directed, except that in no case shall material be deposited less than 4 feet from the edge of a ditch. The Contractor shall maintain all excavations free from detrimental quantities of standing water, leaves, brush, sticks, trash and other debris until final acceptance of the work.

3.26 SUBGRADE AND EMBANKMENT PROTECTION

- A. During construction, embankments and excavations shall be kept shaped and drained. Ditches and drains along subgrade shall be maintained in such a manner as to drain effectively at all times. The finished subgrade shall not be disturbed by traffic or other operation and shall be protected and maintained by the Contractor in a satisfactory condition until subgrade, subbase, base, or pavement is placed. The storage or stockpiling of materials on the finished subgrade will not be permitted. No subgrade, subbase, base course, or pavement shall be laid until the subgrade has been checked and approved, and in no case shall subgrade, subbase, base surfacing or pavement be placed on a muddy, spongy, or frozen subgrade.

END OF SECTION

SECTION 02220

RIPRAP

PART 1 - GENERAL

1.01 SCOPE

Furnish all labor, materials, tools, and equipment and perform all operations necessary for the placement of a protective covering of stone (or a combination of crushed asphalt, brick and concrete overlain by stone) of the size, type, and location shown on the Drawings or as directed by the Owner.

1.02 RELATED WORK SPECIFIED ELSEWHERE

- A. Section 02200 - Earthwork
- B. Section 02596 - Geotextile Fabric

PART 2 - PRODUCTS

2.01 STONE

- A. Stone used for riprap shall be hard, durable angular shaped stones which are the product of the primary crushing of a stone crusher. Rounded stone, boulders, sandstone and similar soft stone or relatively thin slabs will not be acceptable.
- B. The quality of the riprap shall be approved by the Owner.
- C. Riprap shall comply with the following gradation criteria:

<u>Size of Stone</u>	<u>Percent of Rock by Mass</u>	<u>Mass (Lbs)</u>
6 to 8 in.	20	22 to 33
5 to 6 in.	30	11 to 22
2 to 5 in.	40	1 to 11
0 to 2 in.	10	0 to 1

2.02 CRUSHED ASPHALT, BRICK and CONCRETE (Alternate)

- A. Crushed asphalt, brick and concrete (ABC) may be used as a supplement to the riprap stone at the locations shown on the drawings and as specified herein.
- B. Crushed ABC shall meet the gradation requirements for riprap stone as specified above.
- C. Crushed ABC shall be mechanically screened to be free of metal, debris and fine soils.

PART 3 - EXECUTION

3.01 RIPRAP STONES

- A. Riprap stones shall be placed on the prepared area in a manner which will produce a well graded mass with a minimum practical percentage of voids. The riprap stone shall be placed to the minimum thickness of 2.75 feet as shown on the site plans and detail drawings.
- B. The stone shall be placed to its full thickness in one operation and in such a manner as to avoid displacing the underlying material including the 16 ounce geotextile filter fabric.
- C. The placement of the stone shall produce a compact rip rap protected surface in which all sizes of stone are placed in their proper proportions. Hand placing or rearranging of individual stones by mechanical equipment may be required to the extent necessary to achieve the specified result.

3.02 CRUSHED ASPHALT, BRICK and CONCRETE (Alternate)

- A. Crushed ABC materials may be used within the lower component of the slope surface treatment as an alternate to riprap stone.
- B. A uniform layer of crushed ABC may be placed and tamped on the prepared slope area to a final thickness of 1.75 feet. The prepared slope area shall compact and covered with 16 oz. Filter fabric as specified.
- C. Crushed ABC shall be completely covered with a full 1-foot thickness of the specified riprap stone.

3.03 FILTER FABRIC

- A. A 16 ounce non-woven geotextile shall be placed on top of the prepared embankment slope or surface upon which the rip rap stones will be placed, unless shown otherwise on the Drawings. Refer to SECTION 02596, Geotextile Fabrics.

END OF SECTION

SECTION 02500
HDPE GEOMEMBRANE

PART 1 - GENERAL

1.01 DESCRIPTION OF WORK

- A. The Contractor shall furnish all labor, materials, supervision, and equipment to install the HDPE geomembrane including, but not limited to panel layout, seaming, patching, and testing, and all necessary and incidental items required to complete the Work, in accordance with the Drawings and these Specifications. The Contractor shall also furnish all labor, materials, supervision, and equipment to excavate and backfill the anchor trench for the Geomembrane, as shown on the Drawings.
- B. The Contractor is responsible for conducting compliance testing on representative geomembrane rolls and conducting destructive sample testing from representative field seams. The Contractor shall retain the services of a Geosynthetics Accreditation Institute – Laboratory Accreditation Program (GAI-LAP) certified laboratory to conduct the tests indicated in Parts 2.01 and 3.03 of this Section.
- C. The Contractor shall coordinate geomembrane installation work with the geomembrane sub-grade/gas venting layer placement, sand drainage layer placement and work of others.

1.02 RELATED SECTIONS

- A. Section 02200 - Earthwork
- B. Section 02210 - Sand
- C. Section 02510 - Geocomposite Gas Venting Layer

1.03 REFERENCES

- A. Latest version of the American Society for Testing and Materials (ASTM) standards:
 - 1. ASTM D 638, "Standard Test Method for Tensile Properties of Plastics."
 - 2. ASTM D 746, "Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact."
 - 3. ASTM D 751, "Standard Methods for Coated Fabrics."
 - 4. ASTM D 792, "Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement."
 - 5. ASTM D 1004, "Standard Test Method of Initial Tear Resistance of Plastic Film and Sheeting."

6. ASTM D 1204, "Standard Plastics Test Method for Linear Dimensional Changes of Nonrigid Thermoplastic Sheet or Film at Elevated Temperature."
 7. ASTM D 1238, "Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer."
 8. ASTM D 1505, "Standard Test Methods for Density of Plastics by the Density-Gradient Technique."
 9. ASTM D 1603, "Standard Test Method for Carbon Black in Olefin Plastics."
 10. ASTM D 1693, "Standard Test Method for Environmental Stress Cracking of Ethylene Plastics."
 11. ASTM D 3015, "Recommended Practice for Microscopical Examination of Pigment Dispersion in Plastic Compounds."
 12. ASTM D 4437, "Standard Test Methods for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Geomembranes."
 13. ASTM D 4833, "Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products."
 14. ASTM D 5321, "Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method."
 15. ASTM D 5397, "Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test."
- B. FTMS 101/2065, "Federal Test Method Standard for Puncture Resistance and Elongation Test."
- C. Daniel, D.E. and R.M. Koerner, (1993), *Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities*, EPA/600/R-93/182.
- D. U.S.E.P.A., (1991), *Technical Guidance Document: Inspection Techniques for the Fabrication of Geomembrane Field Seams*, EPA/530/SW-91/051.
- E. NSF Joint Committee on Flexible Membrane Liners, (1993), *Standard 54, Flexible Membrane Liners*, NSF International.
- F. Geosynthetic Research Institute Test Method GM-5 (b), "Single Point Notched Constant Tensile Load (SP-NCTL) Test for Polyolefin Resin or Geomembranes."
- G. Geosynthetic Research Institute Test Method GM-6, "Pressurized Air Channel Test for Dual Seamed Geomembranes."

1.04 LINE AND GRADE CONTROL

- A. Contractor is responsible for line and grade control for all aspects of the work in accordance with the Contract Drawings and these Specifications.

1.05 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Handle and store geomembrane rolls and associated materials in such a manner as to ensure a sound, undamaged condition. Procedures shall be in conformance with manufacturer's recommendations.

1.06 QUALIFICATIONS

- A. The geomembrane manufacturer must have at least five years experience in the manufacture of such geomembrane. In addition, the geomembrane manufacturer shall have produced at least 10 million square feet of similar material.
- B. The geomembrane installer must have at least three years experience in the installation of such geomembrane. Also, the geomembrane installer must have installed at least 10 projects involving a total of 5 million square feet of similar material within the last three years.
- C. The geomembrane installer's supervisor must be on-site and be in responsible charge throughout the geomembrane installation. The supervisor must have supervised the installation of at least 2.5 million square feet of geomembrane.
- D. The geomembrane installer must establish a Quality Control (QC) representative who must be responsible in the field for the quality and integrity of the geomembrane installation, including all testing, inspections and documentation. The QC representative must have performed these duties on at least 2.5 million square feet of geocomposite.

1.07 SUBMITTALS

- A. The Contractor shall submit to the Owner representative samples of the geomembrane and extrudate rod. The Owner may elect to conduct tests on said samples.
- B. The Contractor shall submit quality control certificates provided by the manufacturer on each roll of the geomembrane barrier to the Owner. Test results must document compliance with the specifications in Part 2.01 of this Section.
- C. The Contractor shall submit testing results of pre-construction tests conducted on representative samples of the geomembrane barriers. Such test results must document compliance with the specifications in Part 2.01 of this Section.
- D. The Contractor shall submit geomembrane panel layout drawings to the Owner at least 10 days prior to beginning the installation. The panel layout drawings shall be prepared at scale not less than 1" = 50'. The drawings shall show the location of

geomembrane roll numbers, geomembrane panels, panel numbers, seam locations, geomembrane penetrations and anchor trench.

- E. The Contractor shall submit an "As-Built" panel layout to the Owner within 10 days of completion of the project.

1.08 WARRANTY

- A. A written Warranty shall be provided to the Owner for materials and workmanship of the HDPE Geomembrane.
- B. The manufacturer shall warrant the membrane against manufacturing defects and material degradation for the design conditions for a period of 20 years. The manufacturer shall provide for the replacement of any material that fails for the above stated reasons.
- C. The installer shall warrant the membrane against any defects in the installation or workmanship for a period of 2 years. The installer shall provide for the replacement of any material that fails for the above stated reasons.

PART 2 - PRODUCTS

2.01 HDPE GEOMEMBRANE

- A. Geomembrane shall be made of textured, 40 mil thick, high density polyethylene (HDPE) as noted and to the limits shown on the Drawings.
- B. Geomembrane used shall meet the minimum standards included in Table 02500-1.
- C. The chemical resistance of the Geomembrane material and seams shall be in keeping with typical properties of high quality polyethylene products currently available through commercial sources.
- D. Geomembrane shall be shipped rolled with no seams in the roll.
- E. Extrudate rod shall be manufactured of the same resin type as the geomembrane and shall have the same properties.
- F. Geomembrane materials shall be manufactured by Serrot International, GSE Lining Technology, Inc., Poly-Flex, Inc. or approved equal and shall be tested to the frequencies and physical properties as specified in this Section.
- G. No reclaimed material (that is, material that has seen previous service) shall be allowed in the Geomembrane sheet.
- H. Regrind material (that is, material that has been previously processed by the same manufacturer but has never seen previous service) shall be allowed in the Geomembrane sheet if approved by the Owner.
- I. The Geomembrane shall be free of pinholes and reasonably free from surface blemishes, scratches and other defects as judged by the Owner.

- J. As part of the Contractor's pre-construction testing, interface shear testing shall be performed on each interface of the cap system in accordance with ASTM D5321 or ASTM D6243 for those interfaces involving Geomembrane. Each test shall determine the interface shear strength at normal stresses of 0.5 psi, 2 psi and 4 psi. The geomembrane interfaces shall have the following shear strengths:
1. Geomembrane and each of the Geocomposite Gas Venting Layer / Sand Drainage Layers (under saturated conditions): $\geq 27^\circ$ peak and strengths.

PART 3 - EXECUTION

3.01 CONSTRUCTION - GENERAL

- A. The Geomembrane shall be constructed as soon as practical after placement of the geocomposite gas venting layer. No Geomembrane placement shall take place without specific approval from the Owner. Each sequential section of geomembrane shall be secured in an anchor trench or continuously welded to the adjacent sections as shown on the Drawing and detail.
- B. The geomembrane installer shall issue geomembrane subgrade acceptance forms to the Owner prior to the installation of the geomembrane.
- C. All geomembrane compliance testing must be completed and passed before placing the geomembrane barrier.

3.02 GEOMEMBRANE INSTALLATION

- A. Surfaces to receive liner installation shall be smooth and even, and free of ruts, voids, protrusions, and deleterious material. Vehicles leaking contaminants or causing ruts, pumping, cracking or deformation of surface or otherwise unacceptable to the Owner are not permitted on final dressed surfaces unless authorized by the Owner. Any damage to the surface caused by the Contractor's vehicles shall be repaired at the Contractor's expense.
- B. An anchor trench (as illustrated on the Drawings) will be required at locations indicated along the cap perimeter to secure the Geomembrane. The Contractor shall take precautions to minimize loose soil underlying the Geomembrane in the anchor trenches. The time schedule for excavation and backfilling of the anchor trench is to be approved by the Owner so that the anchor trench remains open for the shortest possible time.
- C. Installation of the Geomembrane shall be as follows:
 1. Unroll only those sections which are to be seamed together or anchored in one day. Panels should be positioned with the overlap recommended by the manufacturer, but not less than 4 in. (76 mm), after the necessary alignment and cutting. Seams shall run parallel with the slope, not across it, wherever possible. If seams must run across a slope, the edge of the upslope sheet shall be positioned above the edge of the downslope sheet. The Geomembrane sections will be placed in an anchor trench which is then backfilled by the Contractor with suitable excavated materials in accordance with the Drawings.

2. After panels are initially in place, remove as many wrinkles as possible. Unroll several panels and allow the material to relax before beginning field seaming. The purpose of this is to make the edges which are to be bonded as smooth and free of wrinkles as possible.
 3. Once panels are in place and smooth, commence field seaming operations.
 4. At the end of each day or installation segment all unseamed edges shall be anchored by rope, sand bags, or other approved device. Sand bags securing the Geomembrane on the side slopes should be connected by rope fastened at the top of the slope section by a temporary anchor. Staples, U-shaped rods or other penetrating anchors shall not be used to secure the Geomembrane. Any damage to the Geomembrane due to wind, rain, hail, other weather predicaments or negligence shall be the sole responsibility of the Contractor.
- D. Field seaming may be extrusion or fusion welding or a combination of these methods. Solvent welding is not acceptable. The Owner reserves the right to reject any proposed seaming method believed to be unacceptable. Additional requirements of proper field seaming include the following:
1. All foreign matter (dirt, water oil, etc.) shall be removed from the edges to be bonded. For extrusion-type welds, the bonding surfaces must be thoroughly cleaned by mechanical abrasion or alternate methods approved by the Owner to remove surface cure and prepare the surfaces for bonding. All abrasive buffing shall be performed using No. 80 grit or finer sandpaper. The grinding shall be performed so that grind marks are generally perpendicular to the edge of sheet. No solvents shall be used to clean the Geomembrane materials.
 2. As much as practical, field seaming shall start from the top of the slope and proceed down slope. This will minimize the development of wrinkles which may occur due to having people working on the side slopes behind the area being seamed. Tack welds (if used) shall use heat only; no double sided tape, glue or other method will be permitted.
 3. The completed cap shall not exhibit any "trampolining" at the time protective cover or other materials are being placed over the Geomembrane.
 4. The seams should be oriented as shown by the approved panel layout drawing, generally parallel to the line of maximum slope. In corners and odd shaped geometric locations, the number of field seams should be minimized.
 5. No horizontal seams should be within 5 ft (1.5m) of the toe of a slope greater than 5%.
 6. No seaming should be attempted above 104°F (40°C) ambient air temperature.
 7. Below 41°F (5°C) ambient air temperature, preheating of the Geomembrane will be required. Preheating may be achieved by natural and/or artificial means (shelters and heating devices). Ambient temperature is measured 6 in. (150mm) above the liner surface. The membrane installation contractor shall

supply instrumentation for measurement of ambient temperature. Trial welds shall be performed at double the specified frequency. Trial welds shall be made under the same conditions as will be experienced in the work-area. All trial testing will be conducted in a heated area after the samples have been allowed to warm to at least 40°F or more. The lowest temperature at which seaming may take place shall be the lowest temperature at which consistent passing trial seams can be produced under simulated work-area conditions. No seaming will be conducted below 20°F.

8. A moveable protective layer of plastic may be required to be placed directly below each overlap of Geomembrane that is to be seamed. This is to prevent any moisture build-up between the sheets to be welded. The protective layer must be removed after seaming is complete unless approved by the Owner. It shall be the Contractor's responsibility to determine the need for such a protective layer.
8. Seaming will extend to the outside edge of panels to be placed in anchor trenches.
9. If required, a firm working surface should be provided by using a flat board or similar hard surface directly under the seam overlap to achieve proper support. The surface must be removed after seaming is complete.
10. No excessive grinding prior to welding shall be permitted. Overground or improperly ground areas shall be replaced at the Contractor's expense.
11. Seams at panel corners of 3 or 4 sheets shall be completed in a fully leak-proof manner. Open ends of all air channels must be welded closed. A patch having a minimum dimension of 24 in. (610mm), extrusion welded to the parent sheet or other approved techniques may be used. The Contractor shall submit a drawing of its proposed seam completion detail and obtain approval from the Owner.

3.03 GEOMEMBRANE TESTING

All Geomembrane sheet and seams will be tested and evaluated prior to acceptance. In general, testing of the sheet will be conducted by the manufacturer. Testing of the seams will be conducted by the Contractor under observation of the Owner. The Owner or a designated, independent geosynthetics laboratory may perform additional testing, as required by these Specifications or as required in the judgement of the Owner to verify that the HDPE sheet and seams meet the specifications. Discretionary testing shall be paid for by the Owner. Testing requirements are detailed in the following subsections:

A. Pre-shipping Sheet Tests

The Contractor or supplier (manufacturer) will be required to submit his Quality Control program to the Owner for approval prior to the shipment of material to the site. As a minimum, the Contractor shall perform the tests at the frequencies given in Table 02500-2 on the HDPE sheet prior to shipping HDPE material to the site. Test results shall be submitted to the Owner 14 days prior to shipping the HDPE rolls unless otherwise approved by the Owner.

- B. The Owner may, at his discretion, conduct conformance testing on the HDPE sheet in order to verify that it meets the minimum standards specified on Table 02500-1. All conformance tests shall be performed by an independent geosynthetics testing laboratory in accordance with the methods presented on Table 02500-1. All conformance test results shall be reviewed by the Owner and accepted or rejected, prior to the placement of the geomembrane. In case of failing test results, the manufacturer may request that another sample be retested by the independent laboratory with the manufacturer's technical representative present during the testing procedures. This retesting shall be paid for by the manufacturer. The manufacturer may also have the sample retested at two different laboratories approved by the Owner. If both laboratories report passing results, the material shall be accepted. If both laboratories do not report passing results, all geomembrane material from the lot representing the failing sample will be considered out of specification and rejected. The manufacturer shall obtain additional samples from rolls immediately before and after the failing roll and test it by the independent laboratory at his/her own expense. If these rolls pass, then only the failing roll will be rejected. If they fail, then the entire lot is rejected. Discretionary testing shall be paid for by the Owner.

C. Trial Test Seams

The Contractor shall maintain and use equipment and personnel at the site to perform testing of test seams. Test seams will be made each day prior to commencing field seaming. These seams will be made on fragment pieces of Geomembrane to verify that seaming conditions are adequate. Such test seams will be made at the beginning of each seaming period; at changes of equipment, equipment settings, weather, or sheet temperature; at the Owner's direction; and at least once every four to six hours during continuous operation of each welding machine. Also, each seamer will make at least one test seam each day. Requirements for test seams are as follows:

1. The test seam sample will be at least 3 ft (0.9m) long by 1 ft (0.3m) wide with the seam centered lengthwise. Ten adjoining specimens 1 in. (25mm) wide each will be die cut from the test seam sample. These specimens will be tested in the field with a tensiometer for both shear (5 specimens) and peel (5 specimens) for single-track fusion welds or extrusion welds. For dual-track fusion welds, the Contractor shall test each track as if it was a single-track weld. Test seams will be tested by the Contractor under observation of the Owner. The specimens should not fail in the weld. The Contractor shall supply qualified personnel and testing equipment. No strain measurements need to be obtained in the field. A passing fusion or extrusion welded test seam will be achieved when the criteria described in Table 02500-1A are satisfied with the exclusion of any strain requirements. If a test seam fails, the entire operation will be repeated. If the additional test seam fails, the seaming apparatus or seamer will not be accepted and will not be used for seaming until the deficiencies are corrected and two consecutive successful full test seams are achieved. Test seam failure is defined as failure of any one of the specimens tested in shear or peel.
2. The Owner will observe all test seam procedures. The remainder of the successful test seam sample will be assigned a number and marked accordingly by the Contractor, who will also log the date, hour, ambient temperature, number of seaming unit, name of seamer, and pass or fail

- a. Peel shall be measured for one sample (that is, five specimens). Peel tests will be evaluated for the criteria described in Tables 02500-1 and 02500-1A.
 - b. Shear shall be measured for one sample (that is, five specimens). Strain measurements are required for the shear specimens. Laboratory tests will be evaluated for the criteria described in Table 02500-1 and 02500-1A.
2. The Owner will observe all production seam field test procedures. Testing for both peel and shear will be evaluated in accordance with Tables 02500-1 and 02500-1A.
3. The Contractor will be responsible for the archive specimen. He will assign a number to the archive sample and mark the sample with the number. He will also log the date, seam number, approximate location in the seam, and field test pass-or-fail description, if applicable. Following completion of the installation of the primary and secondary liners, the archive specimens will be submitted to the Owner.
4. For double-weld seams, all destructive testing shall be performed for each weld to ensure a continuous good weld.

3.04 REPAIR OF DAMAGED GEOMEMBRANE, SAMPLED AND FAILED SEAM AREAS

- A. Damaged and sample coupon areas of Geomembrane shall be repaired by the Contractor by construction of liner strips. No repairs shall be made to seams by application of an extrusion bead to a seam edge previously welded by fusion or extrusion methods. Repaired areas will be tested for seam integrity. Damaged materials are the property of the Contractor and will be removed from the site at the Contractor's expense. The Contractor will retain all ownership and responsibility for the Geomembrane until acceptance by the Owner.
- B. Once the geomembrane has been deployed, the panels must be examined for flaws, holes, defects and tears. Each location requiring a repair shall be repaired using the following procedures:

Patching - A patch shall be used to repair defects in the geomembrane which are 1/8-inch or larger.

Abrading and Re-welding - This procedure may be used to repair seam sections which are less than 10 feet in length.

Spot Welding - Spot welding may be used to repair small tears, pinholes and/or other small defects which are 1/8-inch or smaller.

Capping - Capping shall be used to repair failed seams that are greater than 10 feet in length.

- C. Patches or caps shall extend at least six inches beyond the edge of the defect. The edges of the patch or cap shall be extrusion welded to the in place geomembrane

after both the liners are abraded to remove the surface sheen of the geomembrane and to provide a surface that is more conducive to accepting the weld. Welding of the repair patch or cap shall be completed by extrusion welding the geomembrane. The repairs shall be non-destructive tested using the vacuum-box method as described in this Section.

- D. The Contractor shall not conduct repairs without prior notification of the Owner.

3.05 POTENTIALLY DAMAGING ACTIVITIES

- A. No support equipment shall be allowed on the Geomembrane unless the equipment and protective measures are approved by the Owner. Light-weight portable generators must be placed on protective rub sheets, and stands or supports shall be adequately padded to prevent potential damage to the rub sheet or Geomembrane. All-terrain-vehicles (ATVs) shall not be operated on the Geomembrane. Personnel working on the Geomembrane shall not smoke, wear damaging shoes, or engage in any activity which damages the Geomembrane.

3.06 ANCHOR TRENCH BACKFILLING

- A. The anchor trench will be backfilled and compacted by the Contractor to a dry unit weight not less than 95 percent of standard proctor density determined by ASTM D 698 or 90 percent of the modified proctor density determined by ASTM D 1557. Care should be taken when backfilling the trench to prevent any damage to the Geomembrane. Anchor trench spoil shall be used as backfill material, wherever possible.

3.07 HDPE GEOMEMBRANE BOOT SEALS

- A. HDPE geomembrane boots shall be fabricated around all extraction well piping that penetrates the cap system. The boots shall be constructed in accordance with the Geomembrane Boot detail shown on Drawing No. 8.
- B. All boots shall be extrusion welded to HDPE geomembrane cap. All extrusion welds shall be vacuum-box tested in accordance with the requirements of this Section.
- C. Boots shall be extended to a minimum height of 18 inches above the final landfill surface so that they may be inspected periodically. A neoprene gasket shall be installed between the extraction well and the boot. Boots shall be affixed to extraction well piping with stainless steel clamps so that the connection becomes leak tight. The clamps will allow for the periodic adjustment of the boot, as needed, to accommodate landfill subsidence without causing damage to the membrane cap or the boot.

**TABLE 02500-1
REQUIRED PHYSICAL PROPERTIES OF HDPE GEOMEMBRANE LINER AND SEAMS**

PROPERTY	TEST METHOD	40-MIL (0.91mm)
Minimum Thickness, mil.	ASTM D5994	36 (-10%)
Minimum Sheet Density, g/cm ³	ASTM D792 or D1505	0.940
Minimum Tensile Properties (each direction) Strength at Yield, lb/in. Elongation at Yield, % Strength at Break, lb/in. Elongation at Break, %	ASTM D6693	84 12 60 100
Minimum Tear Resistance, lbs.	ASTM D1004	28
Dimensional Stability, %, maximum	ASTM D1204 (As modified in NSF54 Appendix A)	±2.0
Stress Crack Resistance, hours	ASTM D5397	200
Minimum Puncture Resistance, lbs.	ASTM D4833	60
Carbon Black Content, (Range in %)	ASTM D1603	2.0 - 3.0
Minimum Peel Strength, lb/in., Fusion Extrusion	ASTM D4437	65 52
Minimum Bonded Shear Strength, lb/in.,	ASTM D4437	81
Melt Flow Index (gr. 10 min)	ASTM D1238-E	<1.0
(Continued on Table 02500-1A)		

TABLE 02500-1A
HDPE WELDED SEAM REQUIREMENTS
(CONTINUED FROM TABLE 02500-1))

Type of Seam	Peel Requirements	Shear Requirements
Fusion	<ol style="list-style-type: none"> 1) Film Tearing Bond failure, 2) No greater separation than 10% of the width of the track being tested subjected to pressure from the roller, and 3) Achievement of required strength 	<ol style="list-style-type: none"> 1) Film Tearing Bond failure, 2) Yield strain is at least 10%, 3) Break strain is at least 50%, and 4) Achievement of required strength
Extrusion	<ol style="list-style-type: none"> 1) Film Tearing Bond failure, 2) No greater than 0.125-inch (3-mm) separation, and 3) Achievement of required strength 	<ol style="list-style-type: none"> 1) Film Tearing Bond failure, 2) Yield strain is at least 10%, 3) Break strain is at least 50%, and 4) Achievement of required strength

FILM TEARING BOND: A failure in the ductile mode of one of the bonded sheets by tearing prior to complete separation of the bonded area.

STRAIN: The strain at yield and strain at break are calculated by the following formula: where

L_w is the length of the weld (outside edge to outside edge of area under pressure),
 L_0 is the original measured grip separation, typically 4.0 in. (100mm) plus L_w and
 ΔL is the change in grip separation at yield or break.

TABLE 02500-2 REQUIRED PRE-SHIPING SHEET TESTING OF HDPE GEOMEMBRANE Primary and secondary liners		
PROPERTY	TEST METHOD	MINIMUM FREQUENCY
Thickness	ASTM D5944	Each Roll
Tensile Properties	ASTM D6693	Each Roll
Sheet Density	ASTM D792 or ASTM D1505	Every Fifth Roll
Carbon Black Content	ASTM D1603	Every Fifth Roll
Carbon Black Dispersion	ASTM D5596	Every Fifth Roll
Tear Resistance	ASTM D1004	Every Roll
Puncture Resistance	ASTM D4833	Every Roll
Dimensional Stability	ASTM D1204 (As modified in NSF54)	Every Tenth Roll
Stress Crack Resistance	ASTM D5397	Every 180,000 lb (81.6 Mg) of Resin*
Melt Flow Index	ASTM D-1238-E	Every 180,000 lb (81.6 Mg) of Resin*
Coefficient of Friction	ASTM D-5321 (Detailed test conditions specified by the Owner)	Once per critical interface

* Or at least once per railcar for railcars containing less than 180,000 lb (81.6 Mg).

END OF SECTION